REMARKS

The Examiner has objected to the length of the Abstract. A substitute Abstract Of The Disclosure, page No. 54, is submitted herein, as well as a marked-up version showing the changes as made.

Claim 1 has been rejected under 35 U.S.C. § 102(b) as being anticipated by International Publication No. WO 97/26039 to Shahinpoor et al. (hereinafter "Shahinpoor"). Additionally, claim 1 has been rejected under 35 U.S.C § 103(a) as being unpatentable over U.S. Patent No. 5,268,082 to Oguro et al. (hereinafter "Oguro") in combination with U.S. Patent No. 4,804,592 to Vanderborgh et al. (hereinafter "Vanderborgh"). Each of these rejections is respectfully traversed.

The present invention is directed to a process for producing an actuator element which functions by bending or deforming electrodes formed on ion-exchange resin products. In the process of the present invention, the metal electrodes are formed on the ion-exchange resin through a process involving adsorbing a metal complex on the ion-exchange resin product, reducing the metal complex by a reducing agent to deposit a metal on the surface of the ion-exchange resin product, and washing the ion-exchange resin product. These steps are repeatedly conducted in the process of the present invention. Such a process is described in detail in the present specification at page 20, line 3, through page 21, line 9, as follows:

> **...In the reduction of the metal complex adsorbed on the ion-exchange resin product, the metal complex is contacted with the reducing agent to deposit a metal on the surface of the ion-exchange resin product. Subsequently, the metal complex present inside the film moves to the vicinity of the film surface (toward the deposited metal) and is then reduced to deposit a metal. That is, crystal growth of a metal proceeds from the surface of the ion-exchange resin product to the interior thereof. Therefore, deposition of the metal is conducted not only on the surface of the ion-exchange resin product but also in the interior near the surface. As a result, the contact area between the ion-exchange resin product and the metal electrode becomes larger than**

> **that in the conventional chemical plating method. Accordingly, by the repetition of the adsorption-deposition process as in the present invention, the metal deposition further proceeds inside the ion-exchange resin product, whereby the contact area between the ion-exchange resin product and the metal electrode is furthermore increased. With increase of the contact area, the number of electrode active spots is increased, and the number of ions migrating to the electrode is also increased. Hence, the difference in water content between the electrodes becomes much larger, and as a result the degree of bending (deformation), namely, degree of displacement, is increased. Moreover, because of the increased contact area between the ion-exchange resin product and the metal electrode, the surface resistance of the electrode is decreased to raise conductivity of the electrode, and the degree of displacement is increased.**

As is apparent, formation of a metal electrode on the ion-exchange resin involves repeating the adsorption, deposition, and washing steps, according to the following scheme:

→ (1) adsorption step → (2) deposition step → (3) washing step →

Claim 1 of the present application claims "wherein the following steps (i) to (iii) are repeatedly conducted to form the metal electrodes...". Since the metal electrode is formed through repeating these steps, the contact area between the ion-exchange resin product and the metal electrode can be increased, thereby increasing the quantity of ions migrating to the electrode. Further, the thickness of the metal electrode can be increased, to reduce the surface resistance of the electrodes, thereby improving the conductivity thereof. As such, the polymeric actuator thus formed is high in the degree of bending (deformation), and is therefore high in the degree of displacement, thus exhibiting quick response.

The Examiner cites Shahinpoor as teaching polymeric actuators prepared by conducting steps (i)-(iii) as in the present invention, and contends that "the disclosures of Shahinpoor are within the language of the instant claims". Shahinpoor is directed to a method for creating an actuator consisting of an ion-exchange material including ion-

exchange resins with an electrode. In Shahinpoor, the electrode formation process includes: (a) rinsing an ion-exchange material; (b) coating the ion-exchange material with a substance which undergoes chemical reduction in the presence of a reducing agent; and (c) reducing the coating on the ion-exchange material by exposing the ion-exchange material to a reducing agent. Shahinpoor teaches coating the ion-exchange resin with a metal, preferably a platinum complex in aqueous solution, followed by reducing the complex with a reducing enhancer, which deposits platinum on the surface. The actuator taught by Shahinpoor is capable of an electrically driven deflection in moist environments.

While Shahinpoor teaches coating an ion-exchange material and reducing the coating to deposit on the ion-exchange material, Shahinpoor fails to teach repeatedly conducting the steps of adsorption, deposition, and washing. As noted above, repeatedly conducting these steps leads to an increase in the contact area between the ion-exchange resin product and the metal electrode, thereby increasing the quantity of ions migrating to the electrode and increasing the thickness of the metal electrode to reduce the surface resistance of the electrode. In fact, the examples of the present application clearly demonstrate the improved results seen through repeatedly conducting such steps. More particularly, the following table sets forth the results demonstrated in Examples 1-9 and Comparative Example 1 discussed at pages 36-41 of the present application:

Table 1 The effect of repeating of steps (1) to (3)

	Repeat time (cycle)	Displacement extent (mm)	Surface resistance (Ω)
Example 1	2	2.0	10
Example 2	3	3.2	5
Example 3	4	3.7	2
Example 4	5	3.9	1
Example 5	6	4.2	1
Example 6	7	4.5	0.5
Example 7	8	5.0	0.5
Example 8	9	5.3	0.5
Example 9	10	5.5	0.5
Co. Ex. 1	1*	2.0	10

* no repeat of steps (1) to (3)

As is clearly seen through the results of these examples, the actuators produced in accordance with Examples 2-9 of the present invention have a higher extent of displacement and a lower surface resistance as compared with the actuator produced in Comparative Example 1, which comparative example does not involve repeatedly conducting the adsorption, deposition, and washing steps. Such improved results as seen through the present invention are not demonstrated through the teachings of Shahinpoor, which fails to teach or suggest repeatedly conducting adsorption, deposition, and washing steps. As such, Shahinpoor fails to anticipate the present invention. Withdrawal of the rejection based on this reference is, therefore, deemed appropriate and is respectfully requested.

Claim 1 has further been rejected as being unpatentable over Oguro taken with Vanderborgh. Oguro teaches the formation of a platinum or gold electrode on the ion-exchange membrane, and teaches that the electrode material can be attached to the ion-exchange membrane through various methods including chemical plating, electrode-plating vacuum deposition, sputtering, coating, pressure adhesion, or the like.

Vanderborgh teaches depositing metals onto electrode substrates including ion-exchange resins through the use of moderate reducing agents such as hydrazine.

The Examiner contends that Oguro fails to disclose step (ii) of the present claims, directed to depositing a metal on the surface of an ion-exchange resin by reduction. The Examiner concludes, however, that it would have been obvious to deposit a metal on the surface by reducing a metal ion according to the teachings of Vanderborgh.

As noted above, claim 1 of the present application clearly requires <u>repeatedly conducting</u> the adsorption step, deposition step, and washing step in order to form the metal electrodes. Nothing in the teaching of Oguru or Vanderborgh, whether considered alone or in combination, teaches or even remotely suggests that the adsorption, deposition, and washing steps can be repeatedly conducted. Moreover, there is no recognition that any such repeated

processing would result in an increase in the contact area between the ion-exchange product and the metal electrode, or an increase in the thickness of the metal electrode, resulting in improved conductivity.

It is apparent from the above discussion that none of the applied references, whether considered alone or in combination, discloses or suggests repeatedly conducting the processing steps of adsorption, deposition, and washing in order to form the metal electrodes. Such processing involving repeatedly conducting these steps is only seen through a hindsight analysis incorporating Applicants' own disclosure. It is well settled, however, that such hindsight analysis is improper as the basis for rejection of a claim.

In view of the above discussions, it is apparent that Oguro and Vanderborgh, whether considered alone or in combination, fail to teach or suggest claim 1 of the present application. Accordingly, the rejection based on the combination of these references should be withdrawn.

It is noted that the additional prior art noted by the Examiner, including U.S. Patent Nos. 4,587,056 to Fukuoka et al., 4,159,367 to Berchielli et al., and 3,892,592 to Fukuda et al., also fail to disclose or suggest claim 1 of the present application involving repeatedly conducting the processing steps of the present invention. Accordingly, these references fail to add any significant teachings to the deficiencies of the references as discussed above.

In view of the above remarks, it is apparent that none of the cited references, whether considered alone or in combination, teaches or suggests claim 1 of the present invention. Accordingly, reconsideration and favorable action are respectfully solicited.

Should the Examiner have any questions regarding any of this information or wish to discuss this matter in further detail, the Examiner is invited to contact Applicants' undersigned representative by telephone.

Respectfully submitted,

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ABSTRACT OF THE DISCLOSURE

A process for producing a polymeric actuator including an ion-exchange resin product and metal electrodes which are formed on the surface of the ion-exchange resin product is provided. The process involves repeatedly conducting the following steps (i) to (iii) to form the metal electrodes ranging from the surface of the ion-exchange resin product to the inside thereof: (i) a step of allowing the ion-exchange resin product to adsorb a metal complex (adsorption step), (ii) a step of reducing the metal complex adsorbed on the ion-exchange resin product by a reducing agent to deposit a metal on the surface of the ion-exchange resin product (deposition step), and (iii) a step of washing the ion-exchange resin product having the deposited metal (washing step). Through the above steps, a polymeric actuator having simple structure, capable of being easily miniaturized, showing quick response and capable of generating large displacement can be obtained.

MARKED UP VERSION OF THE ABSTRACT

[The process for producing a polymeric actuator according to the invention is a] A process for producing a polymeric actuator [comprising] including an ion-exchange resin product and metal electrodes which are formed on the surface of the ion-exchange resin product [and are insulated from each other and functioning as an actuator by applying a potential difference between the metal electrodes in such a state that the ion-exchange resin product contains water to allow the ion-exchange resin product to undergo bending or deformation, wherein] is provided. The process involves repeatedly conducting the following steps (i) to (iii) [are repeatedly conducted] to form the metal electrodes ranging from the surface of the ion-exchange resin product to the inside thereof[;]: (i) a step of allowing the ion-exchange resin product to adsorb a metal complex (adsorption step), (ii) a step of reducing the metal complex adsorbed on the ion-exchange resin product by a reducing agent to deposit a metal on the surface of the ion-exchange resin product (deposition step), and (iii) a step of washing the ion-exchange resin product having the deposited metal (washing step). [By the formation of metal electrodes t] Through the above steps, a polymeric actuator having simple structure, capable of being easily miniaturized, showing quick response and capable of generating large displacement can be obtained.

[The polymeric actuator 1 of the invention comprises an ion-exchange resin product 2 in the form of a slender rectangular flat sheet and metal electrodes 3a, 3b which are formed on the surface of the ion-exchange resin product 2 and are insulated from each other, and the polymeric actuator is designed so that the ion-exchange resin product 2 undergoes bending or deformation by applying a potential difference between the metal electrodes in such a state that the ion-exchange resin product contains an alkylammonium ion-containing

aqueous solution. This polymeric actuator has excellent flexibility, is lightweight, has quick response and is capable of generating large displacement.]